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ABSTRACT

This publication reports on research and development expenditures projected for the year 1985. The support pattern for research and development activities within four major sectors of the economy are considered: industry, government, universities and colleges, and other nonprofit organizations. A summary of the projections methodology is followed by a discussion of the combined research and development expenditures for all sectors. Individual sector projections comprising the national estimates and their respective methodologies are described in detail. (DT)

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1985 R&D FUNDING PROJECTIONS

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FOREWORD

The National Science Foundation has been engaged for more than two decades in an extensive collection and analysis program pertaining to the Nation's science and technology resources. The resulting statistical data series and analyses have been used widely as tools in national, Federal, and institutional policy formulations. Efforts have tended to concentrate on examinations of current situations and past trends. However, as the need for depicting possible future trends became increasingly evident, a modest projection program was started. Development of methodologies and actual projections of science and engineering manpower represented the first outputs of the program. This publication reports on a different thrust, namely projection efforts in the R&D expenditure domain.

This forecast, like any other attempted projection of national R&D funding patterns, cannot cope with unpredictable factors, such as public perception of the value of R&D or major international conflicts, that can significantly affect R&D expenditure levels. However, the methodology used includes studies of past relationships between R&D funding and other economic variables and of the factors responsible for these relationships. Assessments were made of the extent to which the same factors might impact the system during future years, including a series of discussions with knowledgable Government and industry officials.

The report summarizes the methodology and findings of this study and provides projected R&D expenditures for the year 1985. As in any forecast, projected figures depend heavily on the assumptions made. In this case, some of these assumptions involve significant changes from recent trends such as expected increases in constant dollar total R&D expenditures, primarily in the defense area. Changes in trend direction are also expected in the sectoral distribution of Federal R&D funds where the long decline in the share of funds allocated to industry is expected to stop, while the previously increasing shares of Federal intramural laboratories and academic institutions are assumed to remain level. There has been factual evidence for these trend changes in recent years, but only for very limited periods of time which makes their continuation a matter of some uncertainty. The assumptions used and the sensitivity of the projected total R&D expenditures to these assumptions are summarized in the introduction of the report.

It must be emphasized that projections should not be considered predictions because of their dependence on a specific methodology and a series of specific assumptions whose validity is a matter of subjective judgment. Consequently, projected numerical figures should be regarded with caution and should certainly not be considered as precise indicators. Instead, they should be used as rough indications of relative magnitudes of possible future R&D levels. It is also clear that these projections must be reexamined within a few years to assess whether the expected changes, inherent in some of the assumptions, are indeed of a sufficiently long-term nature to justify their use over the entire 10-year period.

It should be kept in mind that this report describes early efforts of the National Science Foundation to project R&D expenditures. Consequently, the methodology is experimental and can undoubtedly be improved. Comments on possible improvements will be greatly appreciated and would help in the development of future projections. The Foundation wants to extend its appreciation to the many Government and industry R&D officials that have already provided useful information based on their insight and experience. The projections themselves were developed in the R&D Economic Studies Section (William L. Stewart, Head) of the National Science Foundation's Division of Science Resources Studies.

Charles E. Falk
Director, Division of Science
Resources Studies

June 1976

acknowledgments

This report was prepared by John R. Chirichiello, Associate Study Director, Industry Studies Group, under the general direction of Thomas J. Hogan, Study Director, Industry Studies Group.

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SUMMARY

• R&D expenditures throughout the four major sectors of the economy are projected to reach over $38 billion in 1985, as measured in terms of 1972 dollars, averaging a 3-percent annual growth between 1974 and 1985.

• The gradual decline in the ratio of R&D expenditures to the gross national product (GNP) experienced since 1964 is expected to continue through 1985 as the GNP is projected to show a more rapid increase than R&D expenditures. By 1985 research and development as a percent of GNP is projected to be 2.0 percent compared to the 2.2 percent expected in 1976.

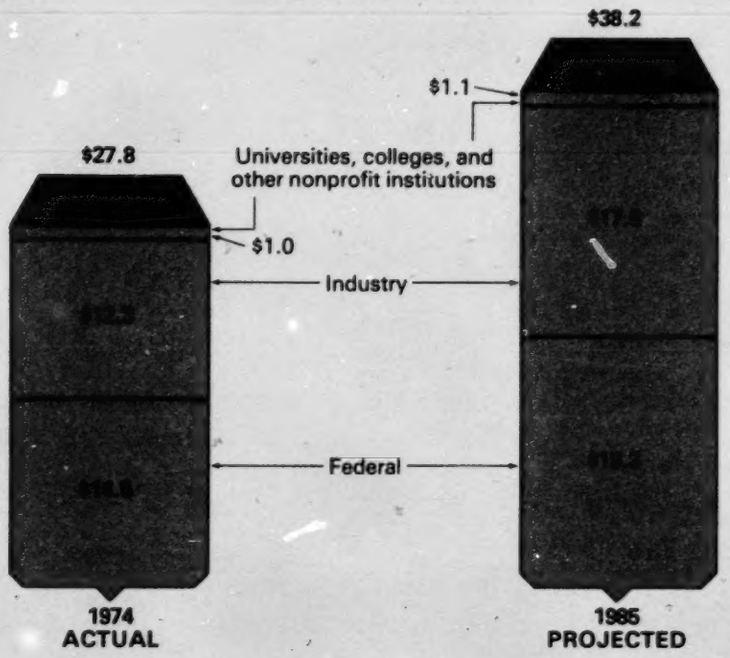
• Industrial R&D spending is expected to grow at an average annual rate of 3.5 percent between 1974 and 1985, mainly because of a projected annual increase of 6 percent in the chemicals industry. Nonmanufacturing industries, while representing a small share of the total, are also expected to show substantial annual growth in R&D expenditures of about 6 percent.

• Federal R&D programs are expected to increase by some 33 percent from the $14.5 billion in 1974 to $19.3 billion in 1985, or by 2.6 percent per year. Defense spending, which accounts for 70 percent of the Federal R&D total, is the major cause of the projected increase. Industry is expected to remain the major performer of Federal research and development with over 50 percent of the Federal total. All performers' shares are expected to remain relatively stable until 1985.

• These projections indicate a leveling of R&D spending by the Nation's universities and colleges and other nonprofit institutions, increasing only an average of 1 percent per year throughout the 1974-85 period. Federal R&D support of these institutions is projected to increase somewhat faster than non-Federal R&D support between 1974 and 1985.

R&D EXPENDITURES

(Billions of 1972 dollars)



SOURCE: National Science Foundation.

INTRODUCTION

Research and development is defined by the National Science Foundation (NSF) as intensive study directed toward fuller scientific knowledge as well as the systematic use of this knowledge directed toward the production of materials, devices, systems, or methods. Since 1953 NSF has carried out a program of intramural and sponsored surveys of R&D spending. It has become increasingly evident during recent years that the support pattern of R&D activities within the four major sectors—industry, government, universities and colleges, and other nonprofit organizations—is undergoing a marked change. For example, decreased emphasis on defense and space R&D efforts has been accompanied by increased support of civilian oriented R&D activities concerned with the numerous social problems facing the Nation.

An examination of likely future R&D spending levels is essential for the assessment of long-term R&D manpower and facility needs. The R&D projections presented here have been developed through the use of relationships between existing data on R&D expenditures and other economic variables in industry and the Federal Government, and the use of recent historical R&D expenditure trend information for universities and colleges and other nonprofit institutions.

The 1985 estimates of total R&D spending in the economy were determined by separately projecting R&D spending of each sector and then summing each of the sector projections. Projections of R&D spending in the private sectors exclude expenditures on federally sponsored R&D projects. Within the industrial sector, essentially the only non-Federal source of R&D spending is industry's own funds; these were projected separately. Within the university and college sector, the non-Federal sources of R&D spending are industry, nonprofit, and institutions' own funds; each source was projected separately. Within the nonprofit sector, the two non-Federal sources are industry and nonprofits' own R&D money; once again each of these sources was projected separately. Projections of Federal R&D expenditures were computed on the basis of total Federal R&D outlays, without regard to the sector in which the work is actually performed.

The major considerations and related assumptions associated with these projections are summarized in the following table. Also shown are sensitivity measures of these projections as they are affected by the various assumed parameters. These sensitivity measures show likely changes in the final projections, assuming a change in only one variable, while holding all other variables unchanged.

For some additional insight into projections of R&D spending, the reader is referred to Charles E. Falk, "Dynamics and Forecasting of R&D Funding," *Technological Forecasting and Social Change*, 1974.

Summary of Projections Methodology

Factor	Assumptions/Methods	Rationale	Sensitivity
A. Industry			
1. Industry R&D/Sales ratios	Industrial R&D growth is proportional to sales growth. It is assumed that the ratio of 2%, which has been relatively level for the last 15 years, will hold for 1985 for manufacturing industries' total.	Historically, variations in R&D/sales ratios have stayed within + — 10% of the 2% average.	10% change in ratio in 1985 results in 5% variation in total R&D funding.
a) Drugs and medicines Machinery Electrical equipment Scientific instruments All other manufacturing industries	Projections of 1985 ratios were based on trend analysis of 1967-74 data.	Analysis provided results similar to expectations of officials within these industries.	10% change in ratio in 1985 results in variations in total R&D funding as follows: Drugs and medicines 0.2% Machinery .7% Electrical equipment .8% Scientific instruments 0 All other manufacturing .9%
b) Industrial chemicals Other chemicals Motor vehicles Aircraft and missiles Optical and other instruments	Projections of 1985 R&D/sales ratios were based on expectations of officials within these industries.	Regression resulted in ratios considered to be unreasonable by industry R&D officials.	10% change in ratio in 1985 results in variation in total R&D funding as follows: Industrial chemicals 0.5% Other chemicals .2% Motor vehicles .6% Aircraft and missiles .2% Optical and other instruments .2%
2. Sales deflation	Conversion of sales projections to constant dollars assumes an inflation rate of 4.6% annually between 1974 and 1985.	Assumption was based on Government (Bureau of Labor Statistics and Department of Commerce) estimates of inflationary trends.	10% change in 1974-85 rate of inflation results in 2% variation in total R&D funding in opposite direction.
3. Industry sales			
a) Product vs. industry basis	Product and industry shipments would increase at same rate between 1974 and 1985.	Historically, product and industry shipments have changed at about the same rate.	10% change in rate of growth between product shipments and industry shipments results in variations of total R&D funding of 0.2% in 1985.
b) By 4-digit industry	All industries for which sales estimates are not available (15% to 20% of the total) would increase at the same rate as those for which sales estimates are available.	Historical data covering the 1958-67 period show both groups increasing at similar rates.	10% change in growth results in variations of total R&D funding of 0.3% in 1985.
c) Enterprise vs. establishment basis	Enterprise and establishments sales would increase by the same relative rates between 1974 and 1985 as they did between 1958 and 1967.	Historical data covering the 1958-67 period are the latest available data.	10% change in rate of growth results in variation in total R&D funding of 1.6% in 1985.
d) R&D performers vs. non-R&D performers	Sales of both groups would increase at the same rate between 1974 and 1985.	Historical data for the 1958-67 period show sales of both groups increasing at similar rates.	10% change in rate of growth results in variation of total R&D funding of 1.6% in 1985.

Summary of Projections Methodology — Con.

Factor	Assumptions/Methods	Rationale	Sensitivity
A. **Industry** — Con.			
4. Non-manufacturing R&D	R&D funds would be 3% of manufacturing total in 1985, based on trend regression of 1967-74 data.	Regression results in 1985 ratio considered reasonable, based on growing R&D involvement of nonmanufacturing firms.	10% change in ratio results in variation of total R&D funding of 0.1% in 1985.
B. **Federal Government**	Federal R&D proportional to Federal purchases of goods and services.	R&D is a purchased service. A comparison of Federal purchases and R&D funding shows strong correlation over 1958-75 period.	10% change in Federal purchases of goods and services results in variation of 6% in total R&D funding in 1985.
C. **University and College**	Non-Federal sources would increase to 1985 at the 1972-75 annual rate.	Studies of universities' financial conditions support assumption for universities' own funds; industry and nonprofit based on past trends.	10% change in rate of growth results in essentially no variation in total R&D funding in 1985.
D. **Other Nonprofit Institutions**	Non-Federal sources would remain level between 1974 and 1985.	R&D funding from non-Federal sources for 1968-75 period indicates leveling off around the 1974 amounts.	10% change in rate of growth results in 0.1% variation in total R&D funding in 1985.

TOTAL R&D

In 1974 the combined R&D expenditures of all sectors of the economy totaled $32.3 billion, the highest level of spending for research and development ever recorded. In constant dollars, as measured by the use of the GNP price deflator, there has been a 1.2-percent average annual decrease from the peak reached in 1968.

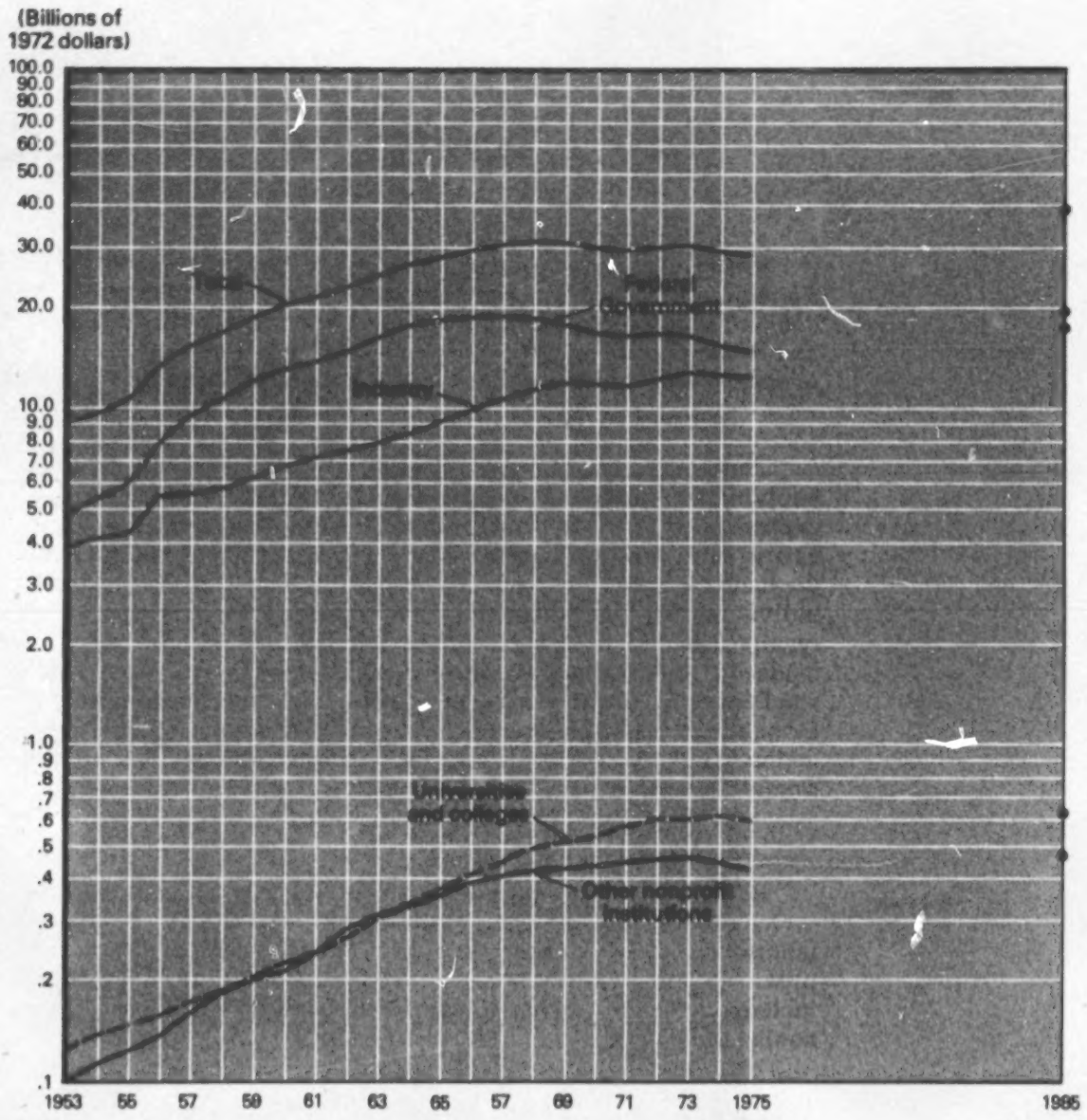
The next 11 years are expected to show a gradual turnaround in this trend with national R&D expenditures averaging a 2.9 percent annual growth through 1985 to $38.2 billion in terms of 1972 dollars.

To demonstrate how changes in the level of R&D investment compare to total economic activity in the United States, R&D expenditures are shown as a percentage of the GNP over time. Since 1964 the ratio of U.S. R&D expenditures to the GNP has shown a gradual decline from 3.0 percent, reaching 2.3 percent in 1974. This decline is projected to continue, reaching 2.0 percent in 1985.

As shown in the chart, all sources of R&D funding are projected to increase between 1974 and 1985, with the major gains registered by the Federal Government and industry. R&D funding by universities and colleges and other nonprofit institutions are expected to increase only slightly between 1974 and 1985.

In the sections that follow, individual sector projections comprising these national estimates and their respective methodologies are described in detail.

Total R&D funds, by source: 1953-85



SOURCE: National Science Foundation.

INDUSTRY

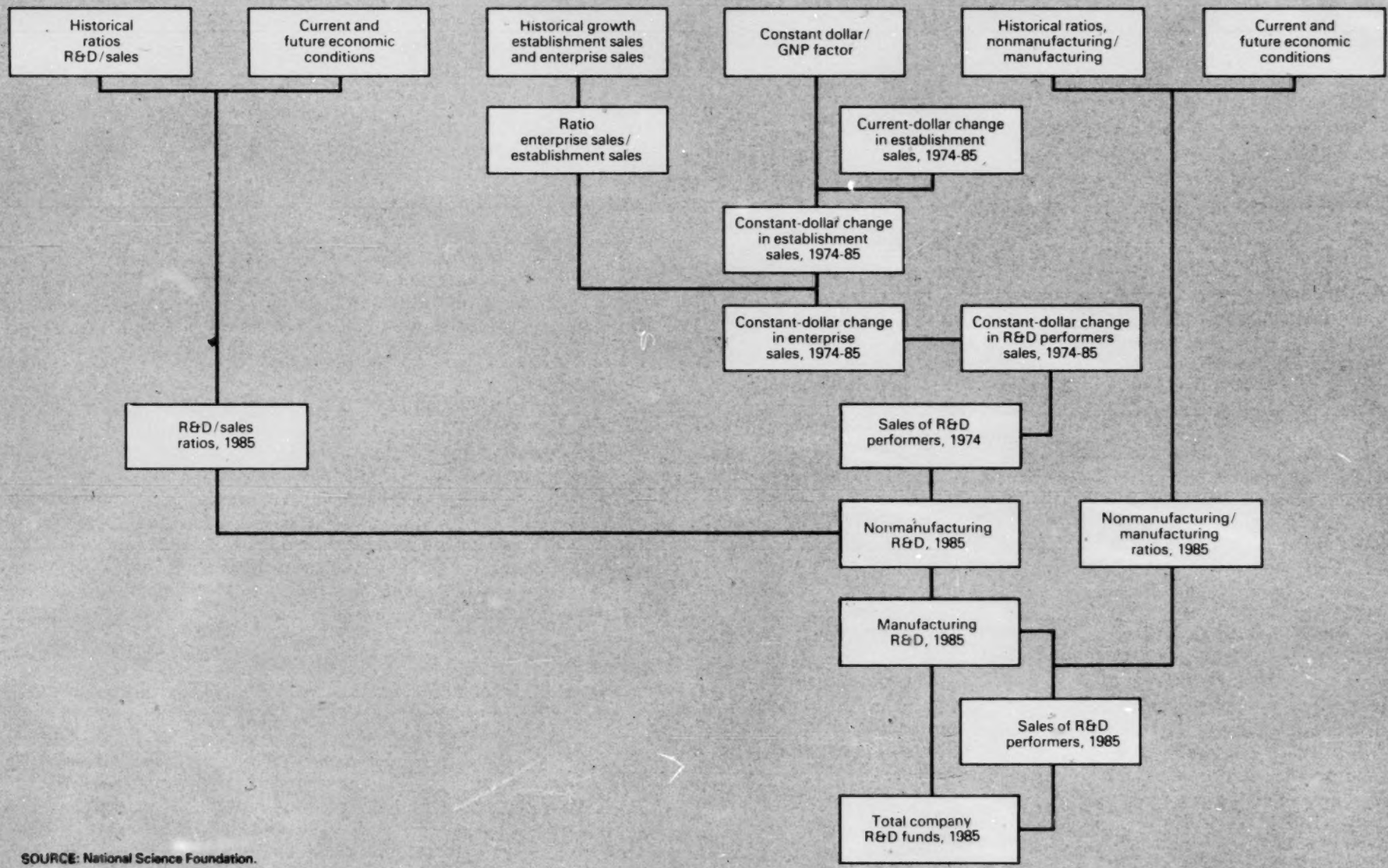
R&D expenditures from industry's own funds are expected to total $17.6 billion in 1985, measured in terms of constant 1972 dollars. This amount, when compared with the level of company-funded research and development in 1974, represents an increase of 46 percent, or an average annual growth of 3.5 percent between 1974 and 1985 (table 2).

These projections were arrived at through two approaches applying similar methodologies to two sets of data. In the first, R&D expenditures of all manufacturing industries were treated as a single entity and their projected totals were added to totals for all nonmanufacturing industries. Then, to provide further insight into individual manufacturing industries and to serve as a check on the results obtained in the first methodology, individual projections were made for the largest R&D-performing industries and the remaining smaller performing industries as a group. These totals were then added to the estimates for nonmanufacturing industries developed in the first methodology. As will be demonstrated, both methodologies produced comparable projections for R&D expenditures for 1985.

Both sets of projections of industry research and development include only those R&D activities performed within industrial laboratories with industry's own money. Industry R&D support provided to universities and colleges or other nonprofit institutions is included with the projections for the university and college and other nonprofit sectors.

The flow chart identifies the major steps taken to arrive at 1985 industry R&D estimates.

Derivation of 1985 estimates of company R&D funds


Historical ratios R&D/sales
Current and future economic conditions
Historical growth establishment sales and enterprise sales
Constant dollar/ GNP factor
Historical ratios, nonmanufacturing/ manufacturing
Current and future economic conditions
Ratio enterprise sales/ establishment sales
Current-dollar change in establishment sales, 1974-85
Constant-dollar change in establishment sales, 1974-85
Constant-dollar change in enterprise sales, 1974-85
Constant-dollar change in R&D performers sales, 1974-85
R&D/sales ratios, 1985
Sales of R&D performers, 1974
Nonmanufacturing R&D, 1985
Nonmanufacturing/ manufacturing ratios, 1985
Manufacturing R&D, 1985
Sales of R&D performers, 1985
Total company R&D funds, 1985

SOURCE: National Science Foundation.

Manufacturing

The basic methodology for projecting manufacturing industry's R&D spending was to apply a 1985 estimated R&D/sales ratio for all manufacturing industries to 1985 estimated sales data for those industries. This technique was repeated for individual two- and three-digit industries[1] and yielded data consistent with the totals obtained by projecting total R&D data for all manufacturing industries ($17.1 billion for the former and $17.4 billion for the latter).

Analysis of survey data spanning a period of more than 20 years reveals a positive correlation (0.9) between the amount of industry money spent for research and development and industry's net sales.[2] For example, between 1967 and 1974, the ratio of R&D spending to net sales for all R&D-performing manufacturing companies has ranged between 1.9 percent and 2.2 percent. When looked at by individual industry, this ratio has also remained relatively constant.

Even when examined back to 1960, the company-funded R&D/sales ratio for all R&D-performing manufacturing companies has remained at about 2 percent (table 3). A lack of comparable data for individual industries prevents examination of the ratios prior to 1967. The U.S. Bureau of the Census, however, has classified each company's total R&D activities since 1967 into the one-industry category representing the company's major business in 1967.

[1] Based on the Standard Industrial Classification (SIC) industry codes.

[2] See National Science Foundation, *Research and Development in Industry* (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office), published annually.

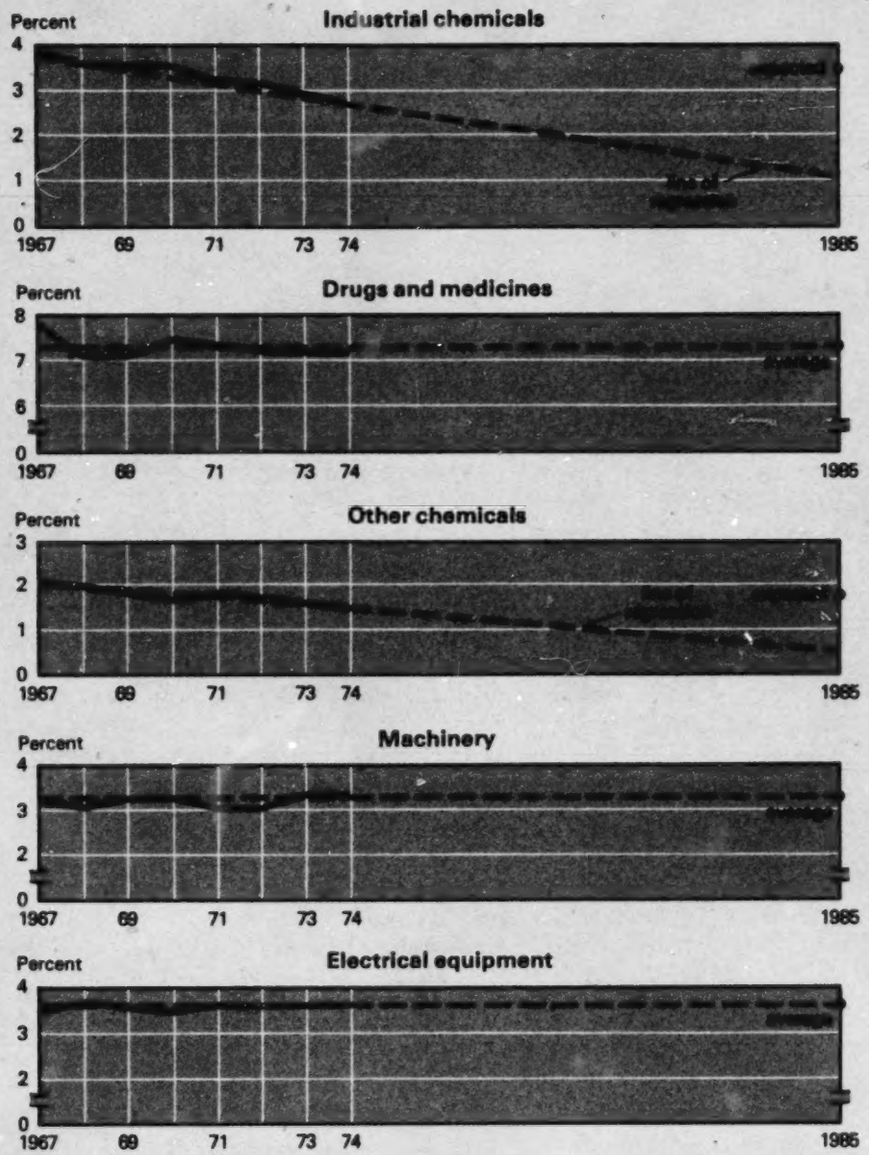
DEVELOPMENT OF R&D/SALES RATIOS FOR 1985

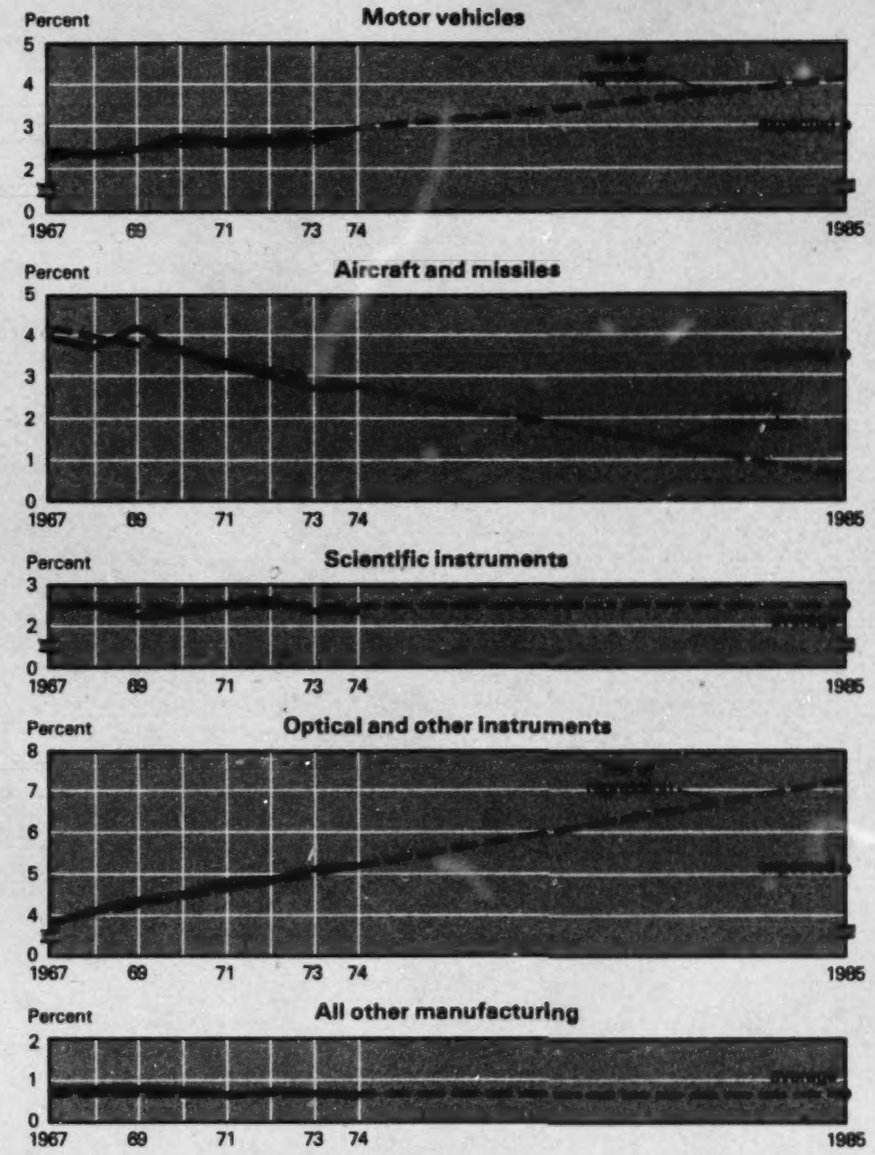
In the first set of projections, R&D/sales ratios for all manufacturing industries during the 1960-74 period were found to vary no more than 10 percent in either direction from a 2-percent average. In view of this stability evidenced over time, it was assumed that this ratio would still be applicable in 1985.

Projections utilizing individual industry data were computed from data on R&D expenditures and net sales for the years 1967 through 1974. The linearity of the relationship between these two factors is demonstrated by the figures in the chart. Based on these observations, the 1967-74 data were extended by industry to 1985 to obtain ratios for that year. For the drugs and medicines, machinery, electrical equipment, scientific instruments, and all other manufacturing industries, the 1967-74 ratios varied only slightly around the averages for those years. These averages resulted in ratios which industry R&D officials accept as reasonable expectations for the actual ratios in 1985 (table 3).

Examination of projected ratios for other industries and discussions with company R&D officials concerning future R&D spending in their industries, however, lead to the rejection of the average for industrial chemicals, other chemicals, motor vehicles, aircraft and missiles, and optical and other instruments industries. Linear trend regression was used for each of these industries to obtain 1985 ratios but was rejected in all cases. For example, linear trend regression would lead to a ratio of zero in industrial chemicals, by 1993, in other chemicals by 1991, and in aircraft and missiles by 1988. In the motor

Industry-financed R&D/sales ratios: 1967-85





SOURCE: National Science Foundation.

vehicles and optical and other instruments industries, unrealistically high ratios would be obtained. For all these industries, therefore, it was necessary to choose alternative projection techniques. The one chosen is subjective but reflects information and opinions of R&D officials in these industries.

In the industrial chemicals industry, it was observed that cutbacks in R&D spending between 1970 and 1972 caused a decrease in the R&D/sales ratio over this period from 3.6 percent to 3.2 percent. Between 1972 and 1974, however, the drop in this ratio to 2.7 percent was largely due to major increases in sales and not to further cutbacks in R&D expenditures. In fact, R&D spending in this industry rose about 15 percent over the latter period as measured in constant dollars. With the current and anticipated energy and materials shortages, R&D officials in this industry foresee an increased dependence on research and development over the next decade. Estimates by these officials of R&D sales ratios ranged between 3.5 percent and 4.0 percent by 1985. On the assumption that company R&D officials may be somewhat optimistic in their forecasts relating to an activity they supervise, the lower of these estimates was used to approximate the 1985 ratio.

In the other chemicals industry, company officials interviewed by NSF staff anticipate increased emphasis on research and development, resulting in expectations of gradual increases in the R&D/sales ratio to between 1.8 percent and 2.2 percent in 1985. Using the same assumption regarding company expectations as in the industrial chemicals industry, the lower of these estimates (1.8 percent) was used to approximate the 1985 ratio.

Within the motor vehicles industry, company R&D officials expect the R&D/sales ratio to increase slightly over present levels. This is based on the assumption of increased R&D emphasis on energy conservation and pollution abatement. Assuming optimism on behalf of these R&D officials, the 1974 ratio of 3.0 percent was used to approximate the 1985 ratio.

Similarly, within the aircraft and missiles industry where total (and Federal) R&D funds dropped sharply in 1970, a number of Federal programs suggest some increases in this industry's R&D activity over the next decade—the B-1 bomber, the Trident missile, the space shuttle, etc. R&D officials expect the R&D sales/ratio to reach at least 3.5 percent by 1985 and perhaps even 4.0 percent. It was felt that the lower of these estimates would approximate the 1985 ratio.

The same basic principle was employed in the optical and other instruments industry. R&D officials expect only modest growth in this ratio over the next decade. Accordingly, the 1974 ratio of 5.1 percent was used as the 1985 approximation.

Even though the 1985 R&D/sales ratios for some individual industries represent only informed estimates, the application of all these individual industry ratios to sales estimates results in an all-manufacturing ratio of 2.0 percent, the same ratio obtained earlier when data for all manufacturing industries were projected as a group.

DEVELOPMENT OF 1985 SALES ESTIMATES FOR R&D-PERFORMING MANUFACTURING COMPANIES

The 1985 sales estimates of R&D-performing manufacturing companies are based on data contained in the Department of Commerce publication, *U.S. Industrial Outlook, 1976*. The Commerce sales estimates are in current dollars and are based on their current dollar 1985 GNP estimate of nearly $3.6 trillion. In constant 1972 dollars, they estimate $1.9 trillion, the same constant dollar GNP as projected by the Bureau of Labor Statistics (BLS) for 1985. The estimated rate of inflation which results from a comparison of these current and constant dollar GNP estimates is 4.6 percent annually between 1974 and 1985. This is consistent with the rate of GNP inflation estimated by BLS[3] and the Office of Management and Budget.[4] The latter estimates an annual inflation rate of 5 percent a year between 1974 and 1981. However, the later years are estimated at about 4 percent. It should be noted that the Department of Commerce does not have a written methodology available on which their sales estimates are based, so it was impossible to assess the factors which were used in making these sales projections.

From these sales data, constant dollar average annual growth rates between 1974 and 1985 were developed for each industry. The following assumptions were made in developing these estimates:

1. *It was assumed that product shipments[5] and industry shipments[6] would increase between 1974 and 1985 at the same rate.* The sales projections in the Commerce report were made on a 4-digit industry basis[7] and represent, for most 4-digit industries, the value of industry shipments. For some 4-digit industries, however, sales projections were made on a product shipment basis since industry shipment data were not available.[8]

2. *It was assumed that all 4-digit industries for which 1985 sales projections were not available would increase at an annual rate equal to the weighted average of the 4-digit industries for which data were available.* The *U.S. Industrial Outlook* does not make sales projections for all 4-digit industries; only the larger ones are shown. For the 2- and 3-digit industries—chemicals, machinery, electrical equipment, motor vehicles, aircraft, and instruments—for which R&D projections are being made, sales projections have been made for the 4-digit subindustries which accounted for between 80 percent and 85 percent of the 1974 sales of these 2- and 3-digit industries.

3. *It was assumed that the relationship between the growth in enterprise[9] sales and the growth in establishment[10] sales between 1974 and 1985 would remain the same as existed between 1958 and 1967.* The *U.S. Industrial Outlook* sales projections were made on an establishment basis and had to be converted to an enterprise basis to be comparable to the R&D data. For each industry, therefore, a comparison was made for the years 1958-67[11] between the growth in enterprise sales data from the *Enterprise Statistics* and the establishment sales figures from the *Census of Manufacturers*,[12] both published by the Bureau of the Census, Department of Commerce (table 4). These ratios were then applied to the average annual change in Commerce 1985 sales on an establishment basis to obtain an average annual change on an enterprise basis for each industry.

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[3] Department of Labor, Bureau of Labor Statistics, *Monthly Labor Review* (Washington, D.C., April 1976).

[4] Executive Office of the President, *The Budget of the United States Government, Fiscal Year 1977* (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1976).

[5] Product shipments include the value of individual products shipped irrespective of the industry code of the establishment shipping them.

[6] Industry shipments include not only the output of a plant of products classified in the industry (primary products) but of products classified in other industries as well (secondary products).

[7] The sales projections for R&D-performing manufacturing companies are based on 2- and 3-digit industries. A 4-digit industry is a subindustry to a 2- and 3-digit industry.

[8] In 1974 sales on a product shipment bases accounted for about 10 percent of the total 1974 sales. The 2-digit primary metals industry accounted for virtually all of this amount.

[9] Each operating plant of a company is classified independently into a specific industry.

[10] All plants of a company are consolidated into one reporting unit and the entire company is classified into a specific industry.

[11] Although some data are available from the *Census of Manufactures* for 1972, data from the *Enterprise Statistics* for this year will not be available until mid-1976.

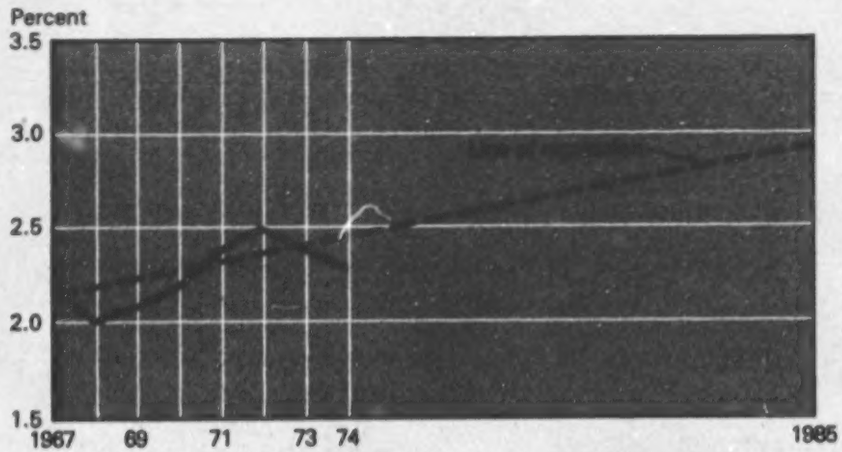
[12] Special treatment had to be given the petroleum refining and extraction industry (SIC 29 and 13). The Census sales figures for 1958 and 1967 did not include Industry 13 (Crude Petroleum and Natural Gas). Data for this industry were derived from Census of Mining data for the years 1958 and 1967. For these years, the sales data for the crude petroleum and natural gas industry were added to the Census total for petroleum refining and related industries (SIC 29). A combined total for the two major 2-digit industries were obtained. Crude petroleum and natural gas made up 43 percent and 44 percent, respectively, of the combined totals. It is assumed that this relationship still holds.

4. Since the sales of R&D-performing manufacturing companies increased at about the same rate as the sales of all companies (R&D performers and non-R&D performers) on an enterprise basis over the 1958-67[13] period, *it was assumed that sales of R&D performers by industry between 1974 and 1985 would increase at the same rate as total enterprise sales over the 1974-75 period.* The 1974-85 growth rates for total enterprise sales were then applied to the 1974 R&D performers' sales data to obtain 1985 sales estimates for R&D-performing manufacturing companies (table 5).

Nonmanufacturing

Since historical R&D data are not available for individual nonmanufacturing industries, the nonmanufacturing sector was treated as an entity. In addition, there is little in the way of projected data for nonmanufacturing industries which can be related to research and development. The Commerce Department, while making sales projections for some nonmanufacturing industries, did not project those nonmanufacturing industries most heavily involved in R&D activities (engineering services, commercial R&D laboratories, and electrical and gas services). Therefore, the techniques used to project manufacturing R&D activities based on sales could not be used for the nonmanufacturing sector. Data for nonmanufacturing industries were derived in the following manner. For the years 1967-74, ratios were computed relating industrial financed research and development in nonmanufacturing industries to company R&D spending in manufacturing industries. Linear trend regression was used to extend this ratio to 1985. Based on discussions with industrial R&D officials, and considering the growing R&D involvement of many nonmanufacturing companies, particularly in the utilities industry, this ratio of 3.0 percent was expected to result in a reasonable 1985 approximation. This ratio was applied to the manufacturing R&D total (obtained by summing the R&D estimates of the individual manufacturing industries) to arrive at estimates of nonmanufacturing R&D data for that year (table 6).

Ratio of nonmanufacturing R&D to manufacturing R&D: 1967-85



SOURCE: National Science Foundation.

[13] Department of Commerce, Bureau of the Census, *Enterprise Statistics: 1967. Part I—General Report on Industrial Organization* (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1972).

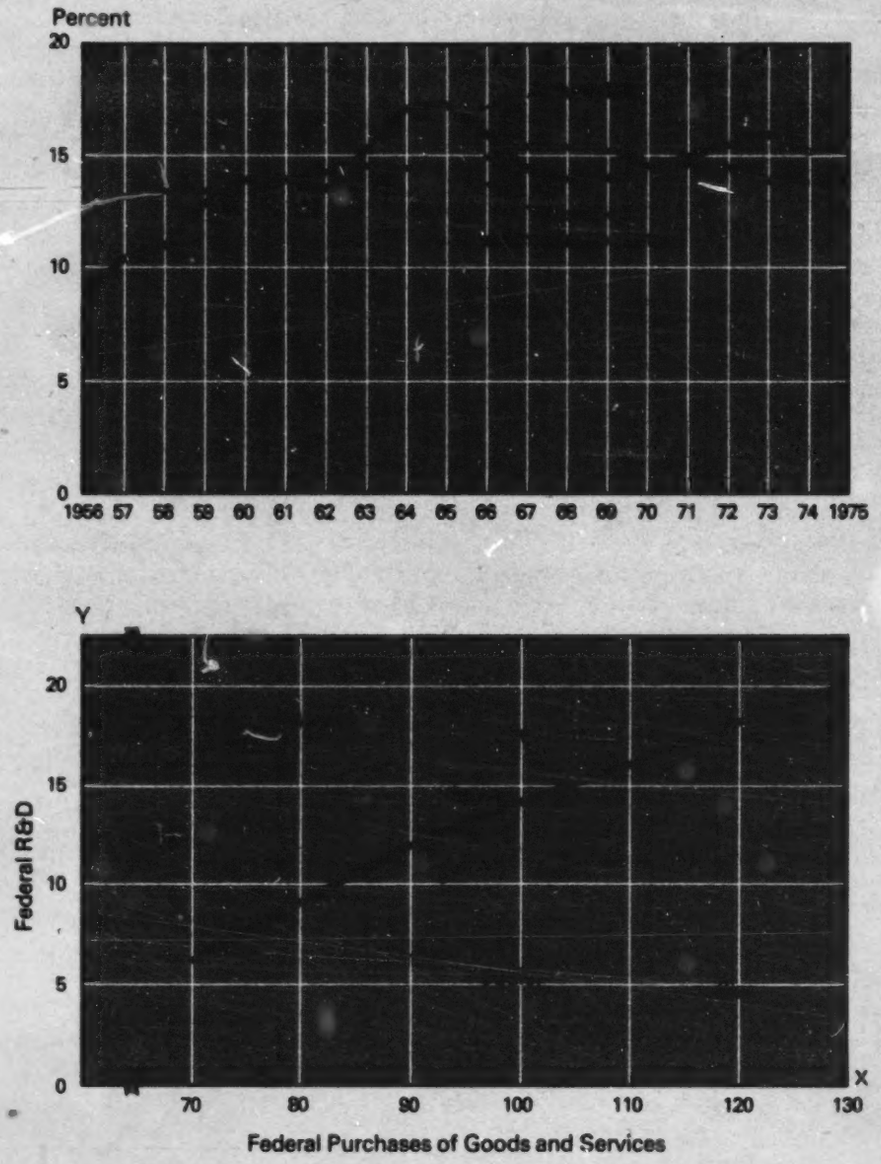
FEDERAL GOVERNMENT

As shown in table 1, Federal R&D funding is projected in 1972 dollars at $19.3 billion in 1985, up 33 percent from the 1974 figure of $14.5 billion. The major factor behind this increase is the projected increase in defense spending by BLS. Defense spending accounts for 70 percent of the Federal R&D total. The 1985 projection was derived by relating historical data on Federal funds for research and development and Federal purchases of goods and services. Through the use of regression analysis, the resulting ratio was applied to 1985 projections of Federal purchases of goods and services.[14]

Since Federal research and development can be viewed as a purchased commodity or service, it was assumed that future R&D funding levels are predictable when related to expected Federal purchases of goods and services. To test this assumption, these two series were compared from 1953 to 1975, the last year for which final R&D data are available (table 7). Each series was converted to 1972 dollars by using the GNP price deflator for Federal R&D spending and the Federal purchases price deflator for Federal goods and services (FGS) before the two series were related.[15] The GNP price deflator which is used to convert Federal R&D spending is not used to convert Federal purchases of goods and services from current to constant dollars since Federal purchases of goods and services include many activities other than research and development, such as defense operations and maintenance, construction, payroll, etc., which contribute to a higher price deflator for Federal purchases of goods and services than for the overall GNP. In the absence of a true R&D cost index, the GNP price deflator is used to convert Federal R&D spending from current to constant dollars. While the GNP price deflator includes the effects of price changes for all goods and services in the economy, it is considered a reasonable indication of changes in R&D costs.[16]

Federal R&D/Federal purchases of goods and services: 1956-75

(Billions of 1972 dollars)



SOURCE: National Science Foundation.

[14] Department of Labor, Bureau of Labor Statistics, *Monthly Labor Review*, *op. cit.*

[15] The GNP and GCS price deflators are developed by the Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office), published monthly.

[16] For example, see National Science Foundation, *A Price Index for Deflation of Academic R&D Expenditures* (NSF 72-310) (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1972) or Helen S. Milton, "Cost of Research Index, 1920-1970," RAC-TP-430. McLean, Va.: Research Analysis Corporation, July 1971.

The relationship between Federal R&D spending and Federal purchases of goods and services has remained relatively constant at 15 percent since 1960. The increase from 1962 to 1965 to over 17 percent was attributable to heavy short-term Federal R&D investments in space activities. During this period, the National Aeronautics and Space Administration's (NASA) R&D spending increased by a factor of 4.

From the data in table 7 a scatter diagram was prepared to determine the nature of the relationship between the two series. By eliminating outlier data for the years 1953-55, the relationship for the remaining years can be described by Federal R&D expenditures (y) = a log Federal purchases of goods and services (x) + b. The slope, a, = 50.299 and the intercept, b, = -86.269; the coefficient of correlation r, = .81. The estimating equation line has been plotted on the scatter diagram.

By eliminating data for earlier years, the relationship between the two series could change. For example, if 1953-59 data were eliminated, the period when Federal R&D was experiencing significant growth, the relationship could take the form of $y = ax + b$, or $y = a \log x + b$. Since the resulting equations had somewhat lower correlation coefficients, they were discounted in the projections of Federal R&D spending to 1985.

By using only data from 1967 on, the relationship takes the form $y = ax + b$, yielding an estimated Federal R&D figure of about $9 billion for 1985. Even though this time period results in an estimating equation with a higher coefficient of correlation, it was discounted because of the limited time period covered, and because of the unrealistically low Federal R&D result for 1985.

BLS has projected Federal purchases of goods and services to 1985 in 1963 dollars.[17] When converted to 1972 dollars, the BLS estimate is $125.5 billion. At first glance, this estimate may appear somewhat high. Between 1975 and 1985, BLS estimates these expenditures to increase by nearly 3 percent per year. This follows the 1968-75 period when Federal purchases of goods and services experienced an average annual decrease of 4 percent a year.

[17] Department of Labor, Bureau of Labor Statistics, *Monthly Labor Review*, *op. cit.*

However, BLS expects a turnaround in defense spending beginning in 1976 and continuing for at least the next 10 years. Defense spending accounts for 70 percent of Federal purchases of goods and services, and defense cutbacks between 1968 and 1975 were the primary cause behind the drop in Federal purchases of goods and services during that time. Increases in defense spending over the next decade are expected to be the major factor behind the projected increases in Federal R&D spending.

These BLS expectations are consistent with information shown in the fiscal year 1977 budget of the U.S. Government. Forecasts of defense outlays, which have a .99 correlation with defense spending over the 1969-75 period, show a 3-percent constant-dollar average annual increase between 1975 and 1981 with emphasis on increased surface/naval capabilities, continuing modernization of equipment, and development of a new ICBM. It should be noted that data after fiscal year 1977 are long-range plans of the Government. Between fiscal years 1977 and 1981, these plans call for an average annual increase of 4 percent in defense outlays.

Applying this estimate of $125.5 billion to the estimating equation results in a 1985 Federal R&D estimate of $19.3 billion, or 15.4 percent of Federal purchases of goods and services during that year. The relationship between Federal R&D spending and GNP would continue to decrease from 1.2 percent in 1975 to 1.0 percent in 1985. Using a different methodology, which has been updated to include data since 1972, C. E. Falk[18] arrived at a somewhat lower 1985 Federal R&D estimate of around $15 billion by assuming a constant-dollar leveling in defense spending after 1977. On the other hand, if overall Federal R&D spending increased to 1985 at the 1975-77 current-dollar rate of 10 percent annually and then converted to 1972 dollars,[19] Federal R&D spending would amount to around $24 billion in 1985.

[18] Charles E. Falk. "Dynamics and Forecasting of R&D Funding," *Technological Forecasting and Social Change*, 1974.

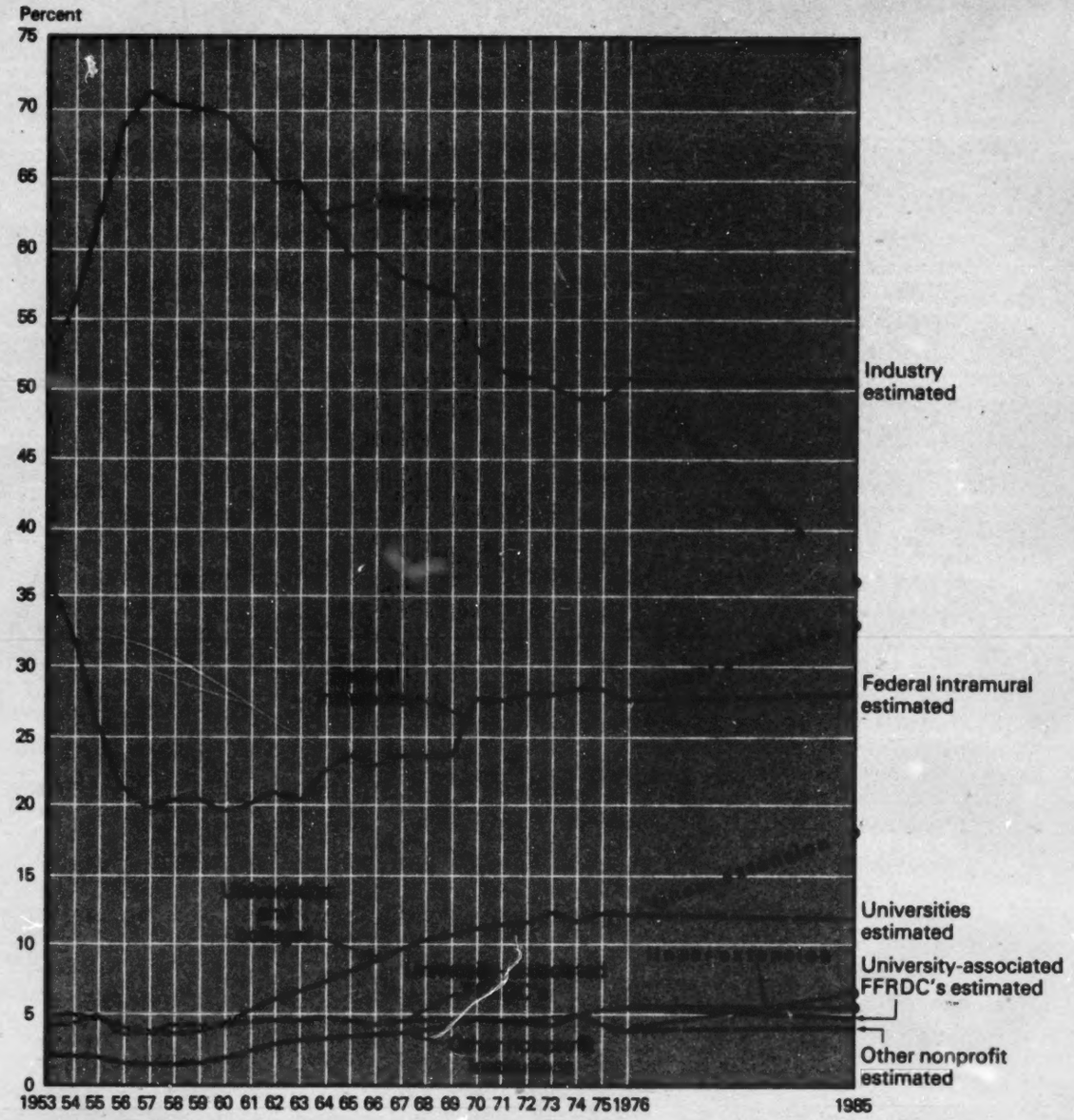
[19] Assumes inflation rate of 4.6 percent annually. See page 11 for discussion on the derivation of this rate.

Distribution by Performer

Once the Federal R&D total for 1985 was determined, a step that went beyond the Federal R&D projections was undertaken. This step attempted to distribute the Federal R&D total among the sectors where the work is to be performed. It should be noted that the distribution of Federal R&D spending by performer has no effect on the total national R&D effort. It is useful, however, in giving an indication of where this Federal money is likely to be spent.

As shown in table 8, the distribution of Federal R&D spending was examined over the period 1953-76. The distribution of Federal R&D funding in the early fifties was undergoing dramatic change, particularly that portion of Federal research and development performed within Federal laboratories and industry. This shift between industrial Government intramural performance occurred when the Federal Government began to look beyond its own laboratories to industry as a source of research and development. Before World War II, the Federal Government carried out its research and development almost entirely in its own laboratories. In response to war-generated needs, a number of Federal agencies, primarily the Department of Defense (DOD) and the Atomic Energy Commission (AEC) began to expand sharply their contracts with organizations in the private sector. Because this produced a substantial change in the pattern of distribution of Federal R&D funds among sectors, it was decided not to use the 1953-56 data in the analysis.

Distribution of Federal R&D funds, by sector: 1953-85



SOURCE: National Science Foundation.

The data from table 8 were analyzed. While they show some linear 20-year-long trends, use of linear extrapolation seems unsuitable for several reasons. The fractions of Federal R&D funds going to universities and colleges, other nonprofit organizations, and Federal intramural efforts have remained relatively constant over the 1967-76 period, particularly in the latter part of this interval. There are no indications that these recent trends will change. Consequently, it was assumed that these proportions would be the same in 1985 as they were in 1976. This automatically has the effect of also maintaining the share of Federal R&D funds going to industry at the 1976 proportional level, thus ending a long-term decline. This change in trend is quite consistent with the expected increasing involvement of industry in Federal energy and defense R&D programs.

For Federal intramural R&D performance, a continuation of the linear time series results in a level of 33 percent of the total. Since 1971, however, Federal intramural performance has remained fairly constant and has averaged 28 percent over this period. It was assumed that this ratio would remain constant in 1985. The university and college-associated Federally Funded Research and Development Centers (FFRDC's) Federal R&D performance is estimated to be 5 percent of total Federal R&D spending for 1985. This ratio was based on the historical relationship between Federal R&D performance of universities and their associated FFRDC's during the 1967-76 period when Federal R&D spending in university and college-associated FFRDC's averaged less than one-half of Federal R&D spending in universities and colleges.

Since Federal R&D funding at nonprofit institutions historically has been slightly lower than that of university-associated FFRDC's, their Federal effort was estimated at 4.5 percent of total Federal R&D spending for 1985.

The amount attributed to university- and college-associated FFRDC's and nonprofit institutions was obtained by subtracting the amount estimated for the other sectors from the projected Federal R&D total. This resulted in a 1985 level for these two sectors of 9.5 percent.

The adjusted 1985 distribution was applied to the Federal R&D totals to obtain Federal R&D performer data for that year (table 9).

UNIVERSITIES, COLLEGES, AND OTHER NONPROFIT INSTITUTIONS

These two sectors perform a small but vital role in the Nation's total R&D effort. In terms of the type of activity undertaken, they account for nearly 70 percent of the total basic research performed in the United States. In terms of the level of funds provided for research and development, however, the combined funding from all non-Federal sources in these two sectors accounts for less than 5 percent of the total. For this reason, projected R&D expenditures for universities and colleges and other nonprofit institutions will have a small impact on national R&D projected amounts.

Universities and Colleges

R&D funds provided to institutions of higher education are projected to increase to $3.2 billion in 1985, in 1972 dollars, from the 1974 level of $2.6 billion (table 2).

The relation between R&D expenditure trend data and selected indicators of campus activities—such as graduate enrollment, educational spending, or doctorate production in the sciences and engineering—was initially examined as a means of projecting R&D expenditures for this sector. For example, both graduate enrollment and doctoral production in science and engineering fields are projected to decrease slightly between 1973 and 1985 if recent trends continue,[20] while educational spending is expected to increase in constant dollars by 1 percent annually between 1975 and 1985.[21] However, based on the relative small size of university R&D spending as compared to overall U.S. R&D spending, it was decided to use historical trends in university R&D spending as the basis for these projections.

[20] National Science Foundation, *Projections of Degrees and Enrollment in Science and Engineering Fields to 1985* (NSF 76-301) (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1976).

[21] Department of Commerce, *U.S. Industrial Outlook, 1976* (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office).

Recent developments in the financial situation of universities and colleges in general have become a cause for major concern among both private and public institutions of higher education. For example, a recent special report by the American Council on Education states, "the overriding conclusion from the present study and earlier evidence is that progressive deterioration has been occurring in the financial conditions of higher education as a whole in recent years. Furthermore, the process of decline appears to have accelerated during the past three years under the joint influence of inflation and recession in the national economy."[22] Another study found that "Among universities, major research institutions appear to have been hardest hit by cutbacks in public funds."[23] The reduced rate of growth in R&D support is a product of these developments.

With regard to the three non-Federal sources of R&D funds in universities and colleges, which include nonprofit institutions, industry, and institutions' own funds, analysis of the R&D spending patterns over the 1970-75 period in terms of constant 1972 dollars show that most of the growth in the non-Federal sources of R&D funds took place prior to 1972 (table 10). Since that time, the rate of growth slowed considerably before increasing again in 1975. Based on these recent trends and on analyses of the financial condition of universities and colleges, such as those cited above, the 1985 level of R&D spending in universities and colleges with non-Federal funds were projected at the 1972-75 average annual growth rate.

[22] Lyle H. Lanier and Charles J. Anderson. *A Study of the Financial Condition of Colleges and Universities: 1972-1975.* (Washington, D.C.: American Council on Education, October 1975), p. 75.

[23] National Commission on the Financing of Postsecondary Education, *Financing of Postsecondary Education in the United States* (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, December 1973).

Other Nonprofit Institutions

Nonprofit institutions are expected to spend, as measured in 1972 constant dollars, $1.3 billion in 1985 on R&D activities (table 2). This is up from $1.1 billion in 1974. The Federal Government, which financed slightly more than two-thirds of the nonprofit 1974 total, is expected to account for a slightly higher share in 1985.

The two non-Federal sources of R&D funds in nonprofit institutions include industry and other nonprofit institutions. The R&D spending patterns of these two sources were analyzed over the 1968-75 period in terms of constant 1972 dollars (table 11). Over this period, R&D spending by the two non-Federal sources of R&D funds has remained relatively level. Based on this factor, the 1985 R&D estimates were maintained at the 1975 amounts.

SELECTED TABLES AND REFERENCES

Table 1.—Total R&D funds, by source

[Millions of 1972 dollars]

Year	Total	Federal Government	Industry	Universities and colleges	Other nonprofit institutions
1974	$27,815	$14,541	$12,266	$579	$429
1985	38,240	19,290	17,830	640	480
Average annual rate of growth:					
1974-85	2.9%	2.6%	3.5%	.9%	1.0%

Source: National Science Foundation.

Table 2.—Total R&D funds, by performer

[Millions of 1972 dollars]

Year	Total R&D	Federal Government		Industry			Universities and colleges					University and college associated FFRDC's		Other nonprofit institutions			
			Source		Sources			Sources					Source		Sources		
		Total	Federal Government	Total	Federal Government	Industry	Total	Federal Government	Industry	Universities & colleges	Nonprofit	Total	Federal Government	Total	Federal Government	Industry	Nonprofit
1974	$27,815	$4,144	$4,144	$19,250	$7,170	$12,080	$2,600	$1,750	$83	$579	$188	$744	$744	$1,077	$733	$103	$241
1985	38,240	5,400	5,400	27,330	9,740	17,590	3,330	2,310	140	640	240	965	965	1,215	875	100	240
Average annual rate of growth: 1974-85	2.9%	2.4%	2.4%	3.2%	2.8%	3.5%	2.3%	2.6%	4.9%	.9%	2.2%	2.4%	2.4%	1.1%	1.6%	-.3%	0

Source: National Science Foundation.

Table 3.—Industry-financed R&D/sales ratios

Industry	1967	1968	1969	1970	1971	1972	1973	1974	1985
All manufacturing	2.1	2.1	2.2	2.2	2.1	2.0	2.0	1.9	2.0
Chemicals:									
Industrial	3.9	3.6	3.6	3.6	3.3	3.2	3.0	2.7	3.5
Drugs and medicine	7.9	7.1	7.1	7.5	7.4	7.2	7.2	7.2	7.3
Other	2.1	2.0	1.9	1.7	1.8	1.7	1.6	1.4	1.8
Machinery	3.2	3.1	3.3	3.3	3.2	3.2	3.4	3.4	3.3
Electrical equipment	3.5	3.7	3.6	3.5	3.6	3.6	3.6	3.6	3.6
Motor vehicles	2.5	2.3	2.5	2.8	2.6	2.6	2.7	3.0	3.0
Aircraft and missiles	4.0	3.7	4.2	3.7	3.3	3.1	2.8	2.8	3.5
Instruments:									
Scientific	2.5	2.6	2.3	2.4	2.6	2.7	2.4	2.4	2.5
Optical and other	3.9	4.1	4.4	4.5	4.9	4.9	5.1	5.1	5.1
All other manufacturing	.8	.8	.8	.8	.7	.8	.7	.6	.75

Note: All manufacturing R&D/sales ratios for 1960 to 1966 were as follows: 1960, 1.8 percent; 1961, 1.8 percent; 1962, 1.9 percent; 1963, 1.9 percent; 1964, 2.0 percent; 1965, 2.0 percent; and 1966, 2.0 percent.
Source: National Science Foundation.

Table 4.—Enterprise/establishment sales comparisons

[Dollars in millions]

Industry	Enterprise			Establishment			Enterprise change/ establishment change
	1958	1967	Annual percent change	1958	1967	Annual percent change	
All manufacturing	$336,935	$581,092	——	$338,361	$574,854	——	——
Chemicals	21,807	39,802	——	23,129	42,148	——	——
Industrial	11,154	21,281	7.44	11,780	21,417	6.87	1.08
Drugs and medicines	2,794	4,973	6.61	2,978	5,302	6.62	1.00
Other	7,859	13,548	6.23	8,371	15,429	7.02	.89
Machinery	23,159	47,122	8.21	22,798	48,477	8.74	.94
Electrical equipment	21,685	51,646	10.12	19,548	43,361	9.26	1.09
Motor vehicles	22,824	47,056	8.37	25,073	47,448	7.35	1.14
Aircraft and missiles	15,412	33,383	8.97	16,903	30,332	6.71	1.34
Instruments	4,779	11,335	——	4,419	9,907	——	——
Scientific	1,852	3,216	6.32	1,839	3,074	5.78	1.08
Optical and other	2,927	8,119	12.00	2,580	6,833	11.43	1.05
All other manufacturing	227,269	350,748	4.94	226,491	353,181	5.06	.98

Note: —— represents not applicable.
Source: U.S. Department of Commerce.

Table 5.—Sales estimates: 1985

[Millions of 1972 dollars]

Industry	1974-85 annual percent change (establishment basis)	Enterprise change/ establishment change	1974-85 annual percent change (enterprise basis)	Sales of R&D performers	
				1974	1985
All manufacturing	—	—	—	$643,014	$869,045
Chemicals	—	—	—	64,902	100,649
Industrial	3.74	1.08	4.04	35,189	54,401
Drugs and medicines	3.61	1.00	3.61	8,320	12,290
Other	4.82	.89	4.29	21,393	33,958
Machinery	3.83	.94	3.60	54,630	80,610
Electrical equipment	2.02	1.09	2.20	68,698	87,278
Motor vehicles	2.27	1.14	2.59	60,901	80,683
Aircraft and missiles	-5.84	1.34	-3.85	36,528	23,717
Instruments	—	—	—	15,941	25,023
Scientific	5.45	1.08	5.89	3,694	6,933
Optical and other	3.44	1.05	3.61	12,247	18,090
All other manufacturing	3.03	.98	2.97	341,414	471,085

Note: — represents not applicable.
Source: National Science Foundation and U.S. Department of Commerce.

Table 6.—Industry R&D estimates: 1974-85

[Millions of 1972 dollars]

Industry	1974	1985
All industries	$12,082	$17,590
Manufacturing	11,811	17,080
Chemicals	1,850	3,410
Industrial	965	1,900
Drugs and medicines	600	900
Other	285	610
Machinery	1,836	2,660
Electrical equipment	2,503	3,140
Motor vehicles	1,614	2,420
Aircraft and missiles	1,008	830
Instruments	709	1,090
Scientific	87	170
Optical and other	622	920
All other manufacturing	2,091	3,530
Nonmanufacturing	271	510

Source: National Science Foundation.

Table 7.—Federal R&D/Federal goods and services: 1953-75

[Dollars in millions]

Year	Current dollars		Price deflator		1972 dollars		R&D/Goods and services
	Goods and services	R&D	Goods and services	R&D	Goods and services	R&D	
1953	$57.5	$2,759	50.2	58.88	$114.6	$4,686	4.1
1954	47.9	3,138	50.3	59.69	95.2	5,257	5.5
1955	44.5	3,509	51.2	60.98	86.9	5,754	6.6
1956	45.9	4,859	53.4	62.90	85.9	7,725	9.0
1957	50.0	6,119	55.7	65.02	89.8	9,411	10.5
1958	53.9	6,791	58.1	66.06	92.8	10,280	11.1
1959	53.9	8,059	58.7	67.52	91.8	11,936	13.0
1960	53.7	8,752	59.1	68.67	90.8	12,745	14.0
1961	57.4	9,264	60.0	69.28	95.6	12,372	14.0
1962	63.7	9,926	61.8	70.55	103.1	14,069	13.6
1963	64.6	11,219	63.2	71.59	102.2	15,671	15.3
1964	65.2	12,553	65.1	72.71	100.6	17,264	17.2
1965	67.3	13,033	67.0	74.32	100.5	17,536	17.4
1966	78.8	13,990	70.0	76.76	112.5	18,226	16.2
1967	90.9	14,420	72.5	79.02	125.3	18,249	14.6
1968	98.0	14,952	76.4	82.57	128.3	18,108	14.1
1969	97.5	14,914	80.0	86.72	121.8	17,198	14.1
1970	95.6	14,764	86.4	91.36	110.7	16,160	14.6
1971	96.2	14,982	92.6	96.02	103.9	15,603	15.0
1972	102.1	15,887	100.0	100.00	102.1	15,887	15.6
1973	102.0	16,437	106.1	105.92	96.1	15,516	16.1
1974	111.7	16,897	117.6	116.20	95.0	14,539	15.3
1975	123.2	18,577	130.6	126.37	94.3	14,700	15.6

Sources: National Science Foundation and U.S. Department of Commerce.

Table 8.—Percent distribution of Federal research and development, by performer: 1953-76

Year	Federal R&D total	Federal intramural	Industry	Universities and colleges	University and college associated FFRDC's	Other nonprofit institutions
1953	100.0	36.6	51.8	5.0	4.4	2.2
1954	100.0	32.5	55.8	5.1	4.5	2.1
1955	100.0	25.8	62.1	4.8	5.1	2.1
1956	100.0	21.4	68.5	4.4	4.0	1.7
1957	100.0	19.9	70.8	3.7	3.9	1.6
1958	100.0	20.2	70.1	3.7	4.3	1.6
1959	100.0	20.3	69.9	3.8	4.2	1.7
1960	100.0	19.7	69.5	4.6	4.1	2.1
1961	100.0	20.2	67.4	5.4	4.4	2.6
1962	100.0	21.1	64.8	6.2	4.7	3.1
1963	100.0	20.3	64.8	6.8	4.7	3.4
1964	100.0	22.6	61.5	7.3	5.0	3.6
1965	100.0	23.7	59.4	8.2	4.8	3.8
1966	100.0	23.0	59.6	9.0	4.5	3.9
1967	100.0	23.6	58.0	9.8	4.7	4.0
1968	100.0	23.4	57.2	10.5	4.8	4.1
1969	100.0	23.5	56.7	10.7	4.9	4.3
1970	100.0	26.1	52.7	11.2	5.0	5.0
1971	100.0	27.7	51.2	11.5	4.8	4.8
1972	100.0	28.2	50.7	11.6	4.8	4.7
1973	100.0	28.1	50.0	12.4	5.0	4.5
1974	100.0	28.5	49.3	12.0	5.1	5.0
1975	100.0	28.5	49.3	12.3	5.3	4.6
1976	100.0	27.8	50.7	12.2	5.4	4.0
Linear extension						
1985	100.0	33.1	36.1	18.2	5.8	6.8
Linear extension adjusted						
1985	100.0	28.0	50.5	12.0	5.0	4.5

Note: Detail may not add to total because of rounding.
Source: National Science Foundation.

Table 9.—Federal research and development, by performer

[Millions of 1972 dollars]

Year	Total Federal R&D	Federal intramural	Industry	Universities and colleges	University and college associated FFRDC's	Other nonprofit institutions
1974	$14,541	$4,144	$7,170	$1,750	$744	$733
1985	19,290	5,400	9,740	2,310	965	875

Source: National Science Foundation.

Table 10.—Non-Federal expenditures for research and development at universities and colleges, by source: selected years

[Millions of 1972 dollars]

Year	Total	Industry	Universities and colleges	Other nonprofit institutions
1966	$591	$55	$395	$141
1970	753	67	505	181
1972	838	75	576	187
1973	846	81	576	189
1974	850	83	579	188
1975	875	87	590	198
1985	1,020	140	640	240

Source: National Science Foundation.

Table 11.—Non-Federal expenditures for research and development at nonprofit institutions, by source: selected years

[Millions of dollars]

Year	Total	Industry	Other nonprofit institutions
1968	$328	$88	$240
1972	365	108	257
1973	364	108	256
1974	344	103	241
1975	336	99	237
1985	340	100	240

Source: National Science Foundation.

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